subject of the improvement of peasant farmers is ably discussed in Prof. Baldwin's report on the Irish prize farms. R. W.

OUR BOOK SHELF

Oregon: its Resources, Climate, People, and Productions. By H. N. Moseley, F.R.S. (London: Stanford, 1878.)

THIS little manual is the result of a visit paid in July and August last by Mr. Moseley to Oregon. Mr. Moseley gives not only the results of his own observations, but has taken the trouble to consult carefully and give the gist of official publications on the state, the result being a thoroughly satisfactory, full, and trustworthy account of the present condition of Oregon. Mr. Moseley has done a public service in undertaking this task, and we recommend his book to all who contemplate emigrating. It will answer nearly every question an intending emigrant is likely to ask, and gives, moreover, very definite advice as to the kind of people for which the state at present is suited. The book contains an excellent map of the state.

A Handbook of Common Salt. By J. J. L. Ratton, M.D., M.C. Madras College. (Madras: Higginbotham and Co., 1877.)

THIS work is not to be judged as a scientific treatise, but as a practical guide to the manufacture of common salt from sea-water. The author has fulfilled the purpose which he set before himself in compiling the book. Starting with a brief historical introduction, he proceeds to lay before the reader a concise statement of the principal chemical and physical qualities of salt. The occurrence of salt as a mineral is then shortly discussed; the analysis of natural salt occupies a small chapter, which is succeeded by others upon the hygienic value of salt, and upon the agricultural uses of the same substance. The principal rock-salt deposits are described, and the mining operations sketched.

After these chapters, which must be considered as introductory, the composition of sea-water is discussed; the leading facts concerning evaporation of solutions of mixed salts, and fractional precipitation of the saline substances, are clearly laid down, and upon these the theory of salt manufacture is shown to be based.

Details of the salt manufacture are then given, followed by descriptions of the growth of "spontaneous salt," of the manufacture of salt from brine springs, of "earth salt," and lastly, of salt lakes. The final chapter is devoted to a discussion of the bearings of taxation upon the salt trade.

The book is written from the Indian view-point, and is rich in local illustrations of the manufacture; but the author has endeavoured to make, and we think has succeeded in making, the work a really good manual of general applicability.

The author is to be praised for the carefulness with which he has gathered together and arranged a large mass of facts; the result is a most useful and convenient little book of reference. M. M. P. M.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

The "Phantom" Force

THE famous principles of conservation and dissipation of energy, which have done so much to promote the progress of physical science in recent years, were undoubtedly first inferred and generalised from certain similar laws in the theory of forces which, as we find noticed by Prof. Tait in NATURE (vol. xiv. p. 462), were first propounded by Newton.[1] If in any mechanical system, Newton observes, urged by any forces, to which we must add those which arise from friction, the action of a force reckoned *as a gain* in the system is measured by the product of its impulse and the space through which it is pushed back, or as a loss in the system when the product relates to a space through which the force *is allowed to act*, and if as action of the same kind in the system we also count its gains and losses of actual energy of motion, the whole amount of action in the system remains unchanged during the motion. Viewed from the standpoint of the laws of motion, force, and matter, which Newton starts with in the "Principia," and keeping in mind the special definition here given (coinciding with the modern term "potential increase") of the "action" of a force, obviously the reverse of what would vulgarly be called the action of a force *in increasing* a body's energy of motion, this proposition at first looks like a truism; but the idea of potential energy here coined by Newton[2] is really an essential one; and it besides allows the mode of action of some forces of very common occurrence in nature to be described more simply than they could be without it. The force of gravitation, of attraction and repulsion between two bodies permanently electrified or magnetised, and all dual forces or actions and reactions directed along, and depending only on the distance between two bodies, and not at all upon the time, are of this kind. The force can be completely described in these cases (and it may be looked upon in the first instance as only a measure of convenience) by the permanent gradient of energy-variation everywhere; and hence also by the permanent change of energy from one distance to another, when, as is supposed in this example, the dual force pair acts along the line of centres; since then the changes of actual energy which it produces (acting alone upon the bodies) are independent of the rotation of this line, and may be regarded either as produced with the natural motion of this line's rotation or by the same forces acting along a fixed line of centres. When two such bodies approach, or recede from each other, whatever time elapses or whatever course they may pursue about their centre of mass, not only are the momentary transfers between actual and potential energy equal in energy value at every moment of the motion (for this is *general*, and by this condition *only* the bodies returning twice to the same distance from each other might have very different energies of motion at the two returns); but the whole energy of motion which can be gained between two distances is a definite one, and as this would not be so if the bodies returned twice to the same distance with different actual energies, nor if they returned twice to the same distance with different potential energies, it follows at once that not only is the sum of the actual and potential energies at any one distance invariable with the lapse of time and with any intervening motions of the bodies, but since the gain of actual energy from this distance to any other *is the loss* of potential energy, the sum of these two energies is also the same at one distance as it is at another, and it therefore varies neither with the time nor with the distance of the bodies from each other.

In this illustrative example of two bodies (otherwise unimpelled) exerting upon each other a permanent action and reaction, several points connected with the use of the term "potential energy," as just described, require attention. In the first place, whatever the real forces are (acting in "absolute space"[3]) upon the two bodies, the Newtonian laws of motion

[1] On reading the passage again (which I here described from memory) I find that its statement is verbally but not substantially different from what I wrote above, and that in Newton's statement the signs are merely taken oppositely. Newton thus describes an "acceleration" (a gain of actual energy) as a "resistance" (*i.e.*, a force) overcome, with a corresponding loss of action in the system. This is the modern view of equivalence between potential and actual "action" or energy, but *with the signs of* these actions changed.

[2] Newton, in fact, anticipated D'Alembert's principle; and if we apply D'Alembert's principle to the motion of a single particle, the way in which it likewise coincides with the modern definition or recognition of potential energy will presently be understood, although it also reverses the signs of both of the energies concerned.

[3] The term "absolute space," or the simpler word "space," used in Newton's enunciations of the laws of motion as the field of action of "force" is nothing more than a space whose origin is either the centre of mass of all the bodies under actual observation, or any space in which that centre is moving uniformly in a straight line. If we extend our observation to new bodies found not to be moving uniformly in the original space, the old space must be given up, and a new one must be adopted (recognising the new masses), to enable us to state all the forces and to describe the motions completely, of all the bodies under observation (which is the sole problem and

establish that their whole effect in altering the energy of motion of the two bodies at any instant is divisible into two parts, that which the forces, removed to the centre of mass of the pair, and acting there on their joint mass, will have on the joint mass in absolute space, and that which is represented by the sum of the bodies' changes of actual energy reckoned in a space which has this centre of the masses for its origin. If we call the latter changes their local changes of energy, and professing ourselves entirely ignorant of motion and position in absolute space, confine our attention to describing the motions of the bodies in the specified or local space, the abstract laws of dynamics again tell us that in this local space the motion of the bodies is what arises from an equal and opposite action and reaction exerted mutually between them. Suppose this to be of the permanent kind above described (which occurs frequently in natural actions, as already mentioned), then as regards the local motion and its forces (now equal and opposite, and quite distinct from what they were abstractly), the above proposition may be predicated of them which asserts that the local energy of motion and local potential energy together have a constant sum. In our circumscribed sphere of observation the energy of motion is entirely known, or in other words, if we follow the bodies along any course from one point to another, not only all the changes and the sum of the changes of their actual energies, but also their energies at first, and therefore their energies at last, are known by a successive process of integration. We know from the permanency of the energy-gradients along the line of centres that the sum of the energy changes between the two given points is independent of the course or lapse of time in which the final point is reached. Instead, therefore, of making a new successive integration for every course, one such integration for all expresses the total change of energy between the points, and as this is possible for all points or configurations which the bodies can reach from their first configuration, if a scale of such energy changes reckoned from some starting one is made out for all the different distances from each other at which the bodies can be, the scale value will be nothing at the starting distance, and will have determined values at all other distances. We would use the scale by saying that the actual energy at any distance only differs from the scale value by the starting-energy to be super-added; or the excess of the actual energy above the scale value is everywhere constant, and everywhere equal to the actual energy at the initial point. This concise description of the motion, as far as the actual energy at any moment is concerned, accords with the mathematical usage of collecting variable quantities thus simply related to each other and to constant quantities on one side, and constant quantities on the other side of an equality; but a further simplification of its expression is effected if those scale values which mean increase of energy from the starting-point are called "negative," and those denoting loss or decrease of actual energy are called "positive"; for having constructed a new scale on this convention (which we may call the negative scale), to use it we must first change the sign of any value in it before applying the last proposition. As that expression tells us that the remainder, on subtracting the former scale value from the actual energy at any point, is constant, this operation of subtraction, after altering the sign of the new scale value, is simply equivalent to adding the new scale value without altering its sign. With this convention, therefore, that an increase of actual energy is a negative increase, or, in other words, a decrease of the negative scale value, we may put the sentence describing the actual energy in every part of the motion in these much simpler words. The sum of the actual energy and of the negative scale value is everywhere constant and equal to the actual energy at the starting-point of the scale, which we may call the initial actual energy. When increase of actual energy coincides with decrease of "negative scale value" (as we have just seen), and also as it is usual to express it with "work done by a force," increase of negative scale value represents work done against a force as it is expressed in the new phraseology of the science of energy, or with "potential work." The actual energy of the material couplet is everywhere fixed and determinate (when it is once started), but if we speak of the negative scale value as "potential energy" the amount of this at various distances depends upon the distance chosen as the initial one, when it is zero. Thus if we reckon the potential energy of a swinging pendulum, drawn by gravitation towards the centre of the earth (whose motions of rotation and of oscillation relatively to the common centre of the globe and of the pendulum-bob may be disregarded, so that, with the exception of gravity, only a force perpendicular to its motion guides the bob in a space, referred to the common centre as origin, which we may identify with the place of the experiment) from the top of the arc, where the actual energy of the bob is zero, this must be the sum of the values of the actual and potential energies throughout the motion, and consequently at the highest point the potential energy is zero, and everywhere else it is negative, while at the lowest point of the arc, where the actual energy is a maximum, the potential energy reaches its greatest negative value. If, on the contrary, we select the lowest point of the arc as the starting-point, and call the potential energy at this point zero, making the sum of the two in all parts of the motion thereby equal to the greatest value which the actual energy can have, the potential energy must elsewhere supply the deficiency as the actual energy abates, or have positive value in all other positions of the bob, and at the highest points of its swing, when the actual energy entirely disappears, it will reach its greatest positive value, equal to the greatest value of the actual energy at its lowest point. By one such system, therefore, the motion is as perfectly described as by the other, and by a different choice of zero-points the individual amount of the potential energy is thus evidently disposable at pleasure, while its difference between two points yet always remains the same. But by taking the zero point where the actual energy has its greatest value, the advantage is obtained, as in the last arrangement for a pendulum, that the potential, like its partner, actual energy, will never be less than nothing, and its values will always be positive. With its zero point so taken, and with a special choice of mass in the moving body attracted or repelled, whose course is followed, the series of negative scale values or of potential energies just described is termed "the potential" or the "potential function" of the force upon it; but its definition for any permanent force-pair supposes the total absence of all such constraining forces as those of the pendulum string, and the bodies must be left perfectly free to approach or recede from each other to the centre, or to the furthest imaginable distance unimpeded by any forces foreign to the pair. In such material couplets it is also sometimes customary to reckon their combined energies actual and potential in a space having for its origin one of the bodies themselves instead of the centre of their mass. The motion of the standard body then disappears, and that of the other body becomes the relative motion of the two, while at the same time a certain mean mass must be supposed centred in the moving body, so that when the product of this, multiplied by its new acceleration, is taken, its impulse relatively to the stationary body (which is now the rate of change of energy of the pair with the distance between them) may not undergo any alteration by the change of origin. Reckoned in this way, either of the bodies may be said to have energies of motion and configuration in the space relative to the other body, whose sum is constant.

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(*To be continued.*)

purpose of mechanics). If we continue this process until all the bodies of the material universe are brought, with a knowledge of their masses, under our observation, we reach that abstract field of force, or force-space, which is contemplated in Newton's enunciations. This space may be identified with absolute space, because the centre of mass of the universe by which it is defined is as perfectly abstract and metaphysical an idea as any that we can form of absolute space, on the simple ground that we have no reason to attribute to matter a less boundless and limitless extent in the universe than we ascribe to space itself. To define one metaphysical idea by another is not unscientific, nor is the description of force which Newton gives more repugnant to the eyes of common sense than the ideas which we form, though quite indefinite, of the extent of the material universe, and of the boundless realms of space. A special office, it may also be suggested as very probable, may be assigned to force, to avoid the occurrence of superposition and mingling of matter in the same points of space, or to give matter impenetrability.

Aid of the Sun in Relation to Evolution

IT is not often that it will fall to the lot of the physicist to harmonise such important theories as those of evolution and the nebular hypothesis, and much credit is due to the boldness and the originality of Dr. Croll's attempt to do this. At the present time the great majority of scientific men hold the truth of both of these hypotheses in spite of the fact that serious difficulties exist in them which admit of only doubtful explanation, so that it is certain they would be considerably strengthened if it were found possible to dovetail them one to the other without unduly straining the conditions of either. That Dr. Croll has effected this important service is, I think, very questionable, although I fully believe it is attainable.

In advocating his own views in NATURE (vol. xvii. pp. 206, *et seq.*), and in his other publications Dr. Croll has anticipated